

The Dusty Plasma Experiment

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Much the same way dust collects on computer monitors so too does dust respond in space. The electrical forces resulting from a charge on a grain of dust will often be stronger than its gravitational force (weight) and will frequently dominate the interaction within a cloud of dust grains. In a space environment, charged electrons and ions interact with dust grains, resulting in the formation of what is called a "dusty plasma." Dusty plasmas are found in most regions of space. Because of this, charged dust plays a role in understanding space dynamics.¹

The size of spaceborne dust grains can range from 0.1 micron to greater than 1 millimeter in size. The regions of space in which charged dust grains manifest themselves include the Earth's atmosphere, where naturally occurring and manmade aerosols and particles play a significant role in the Earth's energy balance and atmospheric chemistry; high-altitude clouds, where charged ice dust influences radar signals; and the magnetosphere, where they interact with such objects as spacecraft and meteorites and influence the observed plasma and optical signatures. Charged dust particles in the planetary rings of Saturn and Uranus affect the diameter and structure of the rings. Dust particles have been found in the magnetosphere of Mars, comet tails, and in the interstellar medium where they are responsible for the conversion of a significant fraction of the

ultraviolet and visible energy to infrared radiation.

The principal charging mechanisms of dust particles in space are known to be photo-ionization, due to incident ultraviolet light; secondary electron emission, due to collisions with energetic ions and electrons; and absorption of charged particles, due to collisions with thermalized ions and electrons. Because dust is an integral component of the Earth's and other planetary systems, understanding the charging of particles in a space environment is key to understanding observed phenomena.

A laboratory experiment called the dusty plasma experiment has been set up at MSFC in which a single micron-sized charged dust grain is studied at a time. The objective of the research is to experimentally study the interaction of micron-sized particles with electron beams and ultraviolet light. This is done to simulate space-like conditions that affect the charge of a dust grain. Specifically, the experiment will investigate under what conditions and to what extent particles of various compositions and sizes become charged, or discharged, while exposed to an electron beam and ultraviolet radiation environment. The emphasis will be the study of the two charging mechanisms: secondary emission of electrons and photo-ionization.

This experiment is unique in that a single charged dust grain will be studied at a time under stable conditions. Typically, charged dust experiments have employed techniques which study either a cloud of dust grains or individual grains as they pass by. This experiment will use an electrodynamic balance that will

cause a charged dust grain to be stably suspended in an alternating electric field. (Figure 27 is a schematic of an electrodynamic balance.) Once a dust grain of known composition is trapped, its weight (due to gravity) is

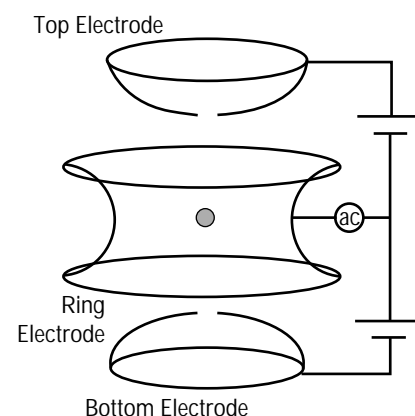


FIGURE 27.—A schematic illustration of an electrodynamic balance where the charge-to-mass ratio of a particle is directly measured. A charged particle will be stably bound in the center of the electrodes, and its weight under gravity will be balanced by a constant electric field.

balanced with a constant offset electric field. In this way, the charge-to-mass ratio of the grain is directly measured. Using light-scattering techniques and viscous drag measurements, the dust grain size and, consequently, its mass is determined. Therefore, the charge of an individual dust grain is measured. The electrodynamic balance is housed in a vacuum chamber and evacuated to pressures less than 10^{-5} torr once a dust grain is trapped. The charge of a dust grain will be measured under

various space-like conditions as it responds to different energies and fluxes of incident electron beams and ultraviolet light.

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The goal of the dusty plasma experiment is to measure the response of an individual dust grain to various space-like environments. In so doing, a better understanding of the fundamental charging mechanisms and of the observed and modeled phenomena of dusty plasmas will be obtained. See figure 28.

Goertz, C.K. 1989. Dusty plasmas in the Solar System. *Rev. Geophys.*, 27, 271.

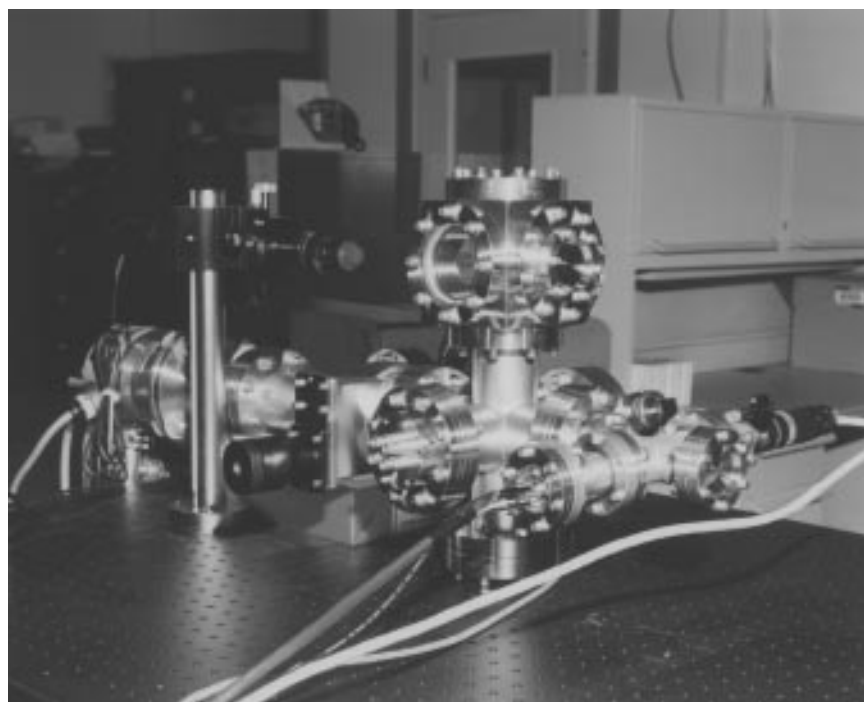


FIGURE 28.—The experimental apparatus for the dusty plasma experiment showing the vacuum chamber. The turbomolecular vacuum pump, used to evacuate the chamber, and the helium-neon laser, used to illuminate the dust grain, are shown in the background. The cube with viewports houses the electrodynamic balance.